Research Article

Heavy Metal Concentration Level in Fluted Pumpkin (*Telfairia occidentalis*) Grown Around Obio/Akpor, Rivers State, Nigeria: Its Health Implications

Njoku-Tony RF[1*] ,Udofia HS[1], Nwoko CO[1], Ihejirika CE[1], Mgbahuruike LU[3], Ebe TE[1] , Egbuawa IO[1], Ezike MN[2]

[1]Department of Environmental Management, Federal University of Technology, Owerri, Nigeria

[2]Department of Animal and Environmental Biology Imo State University, Owerri, Nigeria

[3]Department of Environmental Technology, Federal University of Technology, Owerri, Nigeria

[*]Corresponding Author: Njoku-Tony RF, Federal University of Technology, Owerri, Nigeria, E-mail: tonyrosefeechi@yahoo.com

Received: 27 February 2020; **Accepted:** 10 March 2020; **Published:** 26 March 2020

Citation: Njoku-Tony RF, Udofia HS, Nwoko CO, Ihejirika CE, Ebe TE , Egbuawa IO, Ezike MN. Heavy Metal Concentration level In Fluted Pumpkin (*Telfairia occidentalis*) grown around Obio/Akpor, Rivers State, Nigeria: Its Health Implications. Journal of Environmental Science and Public Health 4 (2020): 16-31.

Abstract

This research work assessed the heavy metal concentration of fluted pumpkin (*Telfairia occidentalis*) grown around Obio/Akpor, Rivers state, Southern Nigeria. Vegetable and soil samples were collected from ten different locations and analyzed for Pb, Cr, Cd, Zn, Cu and Fe using Atomic Absorption Spectrophotometer(AAS), Model: Agilent 55B . Heavy metal concentration was in the order: Fe>Zn>Pb>Cu>Cr>Cd. Mean heavy metals concentration in the vegetables ranged as follows: Zn (7.56-36.77mg/kg), Fe(261.42-416.06mg/kg), Pb(1.00-2.01mg/kg), Cd(0.35-0.55mg/kg), Cu(4.62mg/kg) and Cr(1.49 mg/kg).

The concentrations of all metals were generally within permissible limits set by WHO/FAO for vegetables except Pb, Cd and Cr in some locations.

Trace pollution index (TPI) was highest in Iriebe followed by Oginigba and Rumuodara. The target hazard quotient (THQ), daily intake of metals (DIM), health risk index (HRI) and hazard index (HI) were computed and was found to be within acceptable limits. However, metal uptake by edible vegetables calls for steady monitoring to avoid concentrations exceeding permissible limits.

Keywords: Heavy Metals; *T. occidental*; Daily intake of metals (DIM); Health risk index; Target hazard quotient (THQ); Health risk index (HRI); Hazard index (HI)

1. Introduction

Fluted pumpkin (*Telfairia occidentalis*) is an edible vegetable consumed in West Africa especially Nigeria. It is said to be indigenous to the Southern part of Nigeria [1]. It is used in the preparation of the popular Edikang-Ikong soup among the Ibibio/Efiks. Also, it is used in the popular ugu soup among the Igbos. Fluted pumpkin (T. occidentalis) is widely known for its nutritional, medicinal and economic values. The plant is tolerant to drought and poor soil. Perennial traits observed in fluted pumpkin (*T.occidentalis*) is the fact that its subsisting underground “tuber” could sprout and produce new plant after the first generation fruits have been harvested. *T.occidentalis* has high content of minerals as iron, sodium, potassium, and phosphorus. They also contain vitamins as thiamine and nicotinamide. Fluted pumpkin (*T.occidentalis*) is important in the treatment of diabetes and anemia. It is also used in the prevention and treatment of osteoporosis because of the presence of calcium which helps in bone calcification. Fluted pumpkin (*T.occidentalis*) is also known to contain phytochemicals like phenol. Phenol and its chemical derivatives are essential in the production of pharmaceutical drugs [2]. *T.occidentalis* is of high demand all over Nigeria perhaps because of its nutritional content. Heavy metals such as Copper (Cu), Cadmium (Cd), Zinc (Zn), Lead (Pb), Chromium (Cr) and Iron (Fe) are commonly found on contaminated sites [3]. Heavy metals such as Cu, Zn and Fe are essential micronutrients for plant metabolism. Both essential and non-essential micronutrients when in excess in the human body pose adverse effect on health. Heavy metals can bioaccumulate in the human body via food chain transfer. These contaminated vegetables can have negative effects on human health. Most heavy metals can be very toxic even at low concentrations because there is no good mechanism for their excretion from the body [4].

Previous authors have noted high heavy metal load on vegetables planted in areas of serious anthropogenic activities [5, 6, 7] . And it has been established that the major cause of heavy metal load in vegetables could be due to its uptake of from polluted soil [8,9] and exposure of vegetables to air contaminated with heavy metals [10, 11]. Fluted pumpkin (*T.occidentalis*) contaminations by heavy metals has also been reported by [7, 12] . Other vegetable contaminants due to exposure to polluted air include: sulphur and nitrogen oxides, carbon (II) oxide and soot particles [13, 14] . Studies have shown that uncontrolled urban developments have accounted for high levels of heavy metals in the environment. [15] have reported that leafy vegetables accumulate higher concentration of metals than other food crops. *T.occidentalis* is a major vegetable consumed in the study area, hence, the study investigated concentration of these heavy metals in fluted pumpkin (*T.occidentalis*) and the risk implications.

2. Materials and Methods

2.1 Study area

Obio/Akpor is one of the 23 local governments of Rivers state, south southern part of Nigeria, otherwise called the Niger Delta Region of Nigeria. Obio/Akpor LGA covers about 260 km^2 (100 sq mi), it is a lowland area with average elevation below 30m above sea level. Its geology comprises basically of alluvia sedimentary basin and basement complex [16, 17]. It is bounded by Ikwerre LGA to the north, Port Harcourt LGA to the south, Oyigbo LGA to the East and Emohua LGA to the West [18]. It is located between latitudes 4° 45'N and 4° 60'N and longitudes 6° 50°E and 8° 00'E. According to population census in 2006 (National Bureau of Statistics, 2006) the total population size of Obio/Akpor LGA was 464,789 [19].

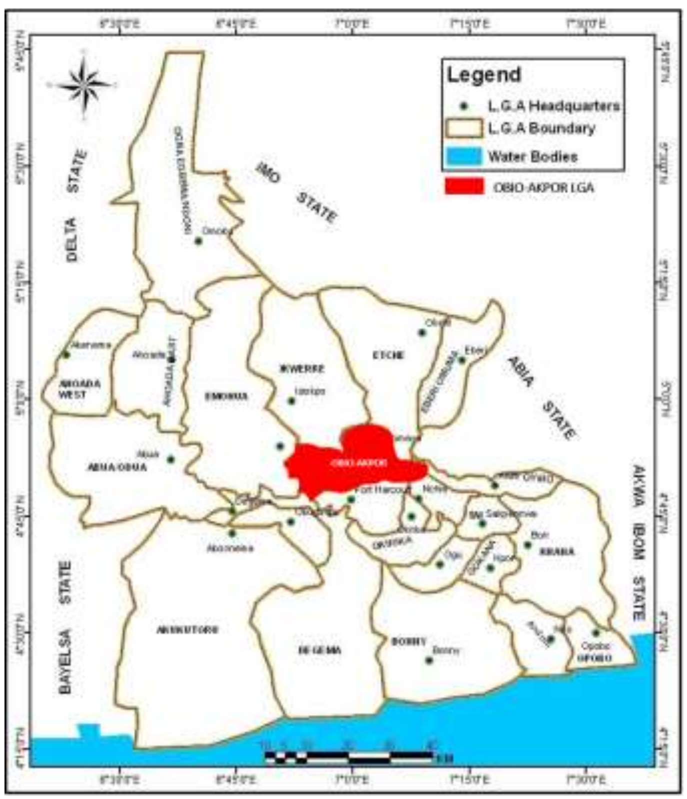
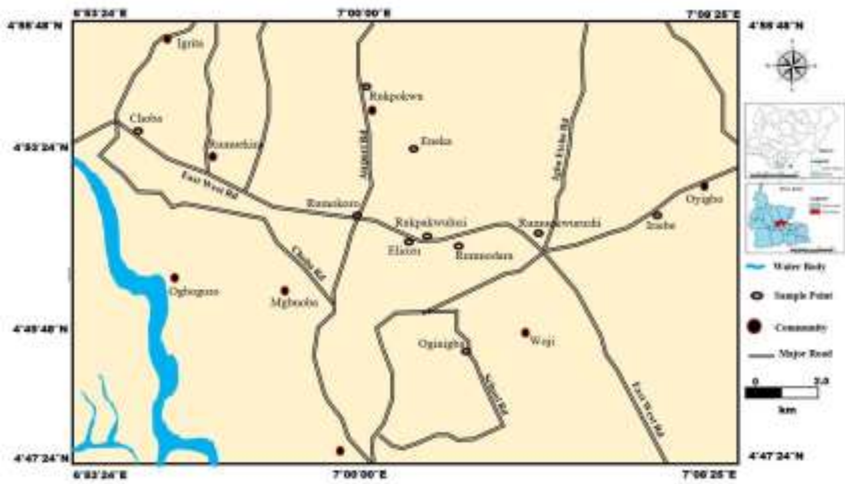


Figure 1: Map of rivers state showing Obio/Akpor LGA.



Cordinates

Longitudes: $6^0$53’24’’E-$7^0$08’25’’E

Latitude: $4^0$47’24’’N-$4^0$55’48’’N

Elevation above sea level: 24.8m

Source: Goggle

Figure2: Map of Obio/Akpor showing study locations.

Obio/Akpor is located in the tropical climate zone with abundant rainfall and little dry season. Rainfall is significant most months of the year, ranging from 2000 and 2500mm with temperature up to 25^0C and a relatively constant humidity [19, 17]. The soil is usually sandy or sandy loam and is always leached due to the heavy rainfall experienced in this area [19, 17] . The vegetation is light rainforest and thick mangrove forest with well drained fresh and salt water. Obio/akpor, located in Port Harcourt metropolis is rich in crude oil, it is home for many industries, filling stations, etc. The popularly known Trans Amadi industrial area is located in this area. The inhabitants of the area are the Ikwerre natives of Rivers State. The inhabitants are mainly farmers and traders. Crude oil activities as well as other economic activities have reduced farmlands for farmers.

2.2 Experimental design and sample collection

The study area was stratified into 3 strata based on the anthropogenic activity viz : High industrial activity, heavy traffic highways and rural areas. The sampling area covered the following communities: Choba, Rumuokoro, Iriebe, Oginigba, Rumuokwurushi, Rukpakwulusi, Eliozu, Eneka,Rukpokwu, and Rumuodara as the control. composite Soil Samples were collected from each stratum at the depth of 0-15cm with soil auger and replicated thrice. Similarly, Fluted Pumpkin (*T.occidentalis*) were obtained from the wild in each of these communities.

2.3 Materials

The materials used include pH meter, model Janway 3510 used to determine soil pH. Electronic balance (Model:WT5002) used to weigh samples. Atomic Adsorption Spectrometer (Model: Agilent 55B) to determine Cu, Cr, Cd, Zn, Pb and Fe concentrations in both vegetable and soil samples, sharp knife for cutting vegetables and soil auger for soil sample collection.

2.4 Sample preparation

Fluted Pumpkin (*T.occidentalis*) were air-dried and blended to pass through 2mm sieve and was taken to the laboratory for analysis. Soils were also sieved to pass through 2mm and analysed for chemical properties.

2.5 Laboratory analysis

2.5.1 Analytical procedure for trace metal determination: The air-dried vegetable samples were sieved using Whatman Filter Paper (2mm). One gram of each of the vegetable sample was weighed using Electronic balance (Model:WT5002) into a 50ml beaker, 5ml of analytical grade acid $HN0_3$ and HCl were added. Mixture was allowed to stay for 5mins, and was heated at a temperature of about 80-90^{0}C for one hour thirty minutes using electric hot plate (HP 220, UTEC products Inc., Albany N. Y., USA) until a clear solution was obtained. After cooling, the solution was made up to a final volume (50ml) with distilled water in a volumetric flask. Similar procedure was carried on 1g air-dried soil samples. The metals (Cu, Cr, Cd, Zn, Pb and Fe) were determined on both vegetable and soil samples using Atomic Absorption Spectrophotometer (AAS) (model: Agilent Technology (Spectra 55B), Australia). Analysis of each sample was replicated and results reported in mg/kg.

2.5.2 Analytical procedure for physicochemical characteristics of soil: The total organic carbon (TOC) was determined using non-refluxing method with slight adjustment [20]. The Cation Exchange Capacity was determined using the method of Chapman, H.D., 1965 (Donald and Quirine, 2012). Semi-micro Kjeldahl method [21] was used to determine Total nitrogen. The method of Piper, (1942) was used to determine the electrical conductivity. The soil pH was determined using pH meter, model Janway 3510. A soil-liquid mixture was established in the ratio 1:25 for each of the soil samples, by dissolving 20g of the sieve samples in 50cm^3 of water in a glass cylinder and the pH was determined by inserting the pH meter in each of the diluted samples. The Core Cutter method was used to determine the bulk density. The moisture content and dry density of each of the soil samples was also determined [22]. The soil textural class was determined using the wet and dry sieve analysis method [23, 24].

2.6 Method of calculating trace metal pollution index (TPI)

Trace Metal Pollution index was determined using the equation by [9].

$$TPI= (TC_1 \times TC_2 \times TC_3 \ldots\ldots TCn)^{1/n} \qquad (1)$$

Where: TC is the concentration of n trace metals in vegetable samples.

2.7 Methods of calculating health risk parameters

Determination of Target Hazard Quotient (THQ) in Exposed Population

The THQ was calculated using the formula below: [25]

$$THQ = \frac{EF \times ED \times FIR \times C}{RFD \times WAB \times TA} \times 10^{-3} \qquad (2)$$

Where: EF is the exposure frequency (350 days/year)

ED is the exposure duration (54 years, equivalent to the average lifetime of the Nigerian population) FIR is the food ingestion rate (vegetable consumption values for South Western adult Nigerian is 65g/person/day) C is the metal concentration in the edible parts of vegetables (mg/kg)

RFD is the oral reference dose (Pb, Cd, Cu, Zn and Cr were 0.0035, 0.001, 0.040, 0.300 and 1.5 mg/kg/day, respectively and the RFD of Fe was 0.65 [26].

WAB is the average body weight (65kg for adult vegetable consumer in South Western Nigeria)

TA is the average exposure time for non-carcinogens (ED x 365 days/year).

2.8 Determination of daily intake of metal (DIM) in exposed population

The DIM was calculated using the equation below:

$$DIM = \frac{C_{metal} \times C_{factor} \times C_{foodintake}}{B_{averageweight}} \qquad (3)$$

Where:

Cmetal is the heavy metal concentration in vegetables (mg/kg)

Cfactor is the conversion factor (0.085). The conversion factor of 0.085 is to convert fresh vegetable weight to dry weight.

Cfood intake is the daily intake of vegetables which was 65g/day .

Baverageweight is the average body weight, which was 65kg for this study.

2.9 Determination of health risk index (HRI) in exposed population

The HRI was calculated using the formula below: [25].

$$HRI = \frac{DIM}{RFD} \qquad (4)$$

2.10 Determination of health index (HI) in exposed population

The HI was calculated using the formula below [27]

$$HI = \Sigma THQ \quad (THQ_1 + THQ_2 + THQ_3 + THQ_4 \ldots\ldots THQ_n) \qquad (5)$$

2.11 Statistical analysis

Data generated were subjected to statistical analysis using Minitab statistical package version 16. one way analysis of variance (ANOVA) was used to partition means and significant means were grouped by Tukey's multiple range tests at 5% significant probability level.

3. Results

3.1 Concentrations of heavy metals in fluted pumpkin in the study area

Trace metal contamination of fluted pumpkin ranged from Cu:0.00 ± 0.00-4.62 ± 0.04mg/kg, Cr:0.00 ± 0.00-1.49 ± 0.0104mg/kg, Cd:0.00 ± 0.00-0.55 ± 0.0104mg/kg, Zn:7.56 ± 0.01-36.77 ± 0.0204mg/kg, Pb:0.00 ± 0.00-2.01 ± 0.0104mg/kg and Fe: 261.42 ± 0.01-416.06 ± 0.0104mg/kg (Table 1).

S/No	Location	Cu(mg/kg)	Cr(mg/kg)	Cd(mg/kg)	Zn(mg/kg)	Pb(mg/kg)	Fe(mg/kg)
1.	Rumuokoro	ND	ND	0.35 ± 0.00[c]	36.77 ± 0.02[a]	1.51 ± 0.01[b]	298.01 ± 0.01[e]
2.	Rumuokwurushi	ND	1.49 ± 0.01[a]	ND	24.12 ± 0.01[e]	ND	382.51 ± 0.01[c]
3.	Iriebe	ND	ND	ND	22.59 ± 0.01[f]	1.51 ± 0.01[b]	416.06 ± 0.01[a]
4.	Oginigba	ND	ND	ND	30.64 ± 0.01[b]	2.01 ± 0.01[a]	384.72 ± 0.01[b]
5.	Eliozu	ND	ND	0.55 ± 0.01[a]	30.20 ± 0.01[c]	ND	275.61 ± 0.01[g]
6.	Choba	ND	ND	ND	10.13 ± 0.06[i]	ND	287.41 ± 0.01[f]
7.	Eneka	ND	ND	ND	20.43 ± 0.01[h]	1.00 ± 0.00[c]	357.71 ± 0.01[d]
8.	Rumuodara	ND	ND	ND	7.56 ± 0.01[j]	ND	261.42 ± 0.01[h]
9.	Rukpakwulusi	ND	ND	0.45± 0.001[b]	21.08 ± 0.01[g]	ND	296.86 ± 2.32[e]
10.	Rukpokwu	4.62± 0.04[a]	ND	ND	29.24 ± 0.01[d]	ND	273.62 ± 0.01[g]

Columns bearing the same letters are not significantly different at 5% probability level; ND = Not Detected

Table 1: Heavy metal concentration (mg/kg) of fluted pumpkin in the study area.

Columns bearing the same letters are not significantly different at 5% probability level.Soil trace metal contamination ranged from Cu:8.60 ± 0.01-17.51 ± 0.0104mg/kg, Cr: 12.77 ± 0.03-19.95 ± 0.0104mg/kg, Cd: 0.35 ± 0.001-3.45 ± 0.00204mg/kg, Zn: 15.82 ± 0.01-51.50 ± 0.0104mg/kg, Pb: 5.00 ± 0.01-8.50 ± 0.0004mg/kg and Fe: 857.69 ± 0.01-875.47 ± 0.0304mg/kg (Table 2).

The trace metal pollution index (TPI) recorded the highest value (21.00) in Oginigba followed by Choba (19.92) and Rumuokwurushi (14.27).

Location	Cu(mg/kg)	Cr(mg/kg)	Cd(mg/kg)	Zn(mg/kg)	Pb(mg/kg)	Fe(mg/kg)	TP1
Choba	8.60 ± 0.01[c]	12.77 ± 0.03[c]	3.45 ± 0.002[a]	27.03 ± 0.06[b]	5.00 ± 0.01[c]	857.69 ± 0.01[c]	19.92
Rumuokwurushi	9.81 ± 0.01[b]	19.95 ± 0.01[a]	0.35 ± 0.001[c]	15.82 ± 0.01[c]	6.50 ± 0.01[b]	875.47 ± 0.03[a]	14.27
Oginigba	17.51 ± 0.01[a]	17.93 ± 0.06[b]	0.50 ± 0.006[b]	51.50 ± 0.01[a]	8.50 ± 0.00[a]	873.37 ± 0.06[b]	21.00

Table 2: Heavy metal concentration (mg/kg) of soil in the study area.

Columns bearing the same letters are not significantly different at 5% probability level. pH varwied from 8.943 ± 0.006-9.033 ± 0.006, Electrical Conductivity (EC) varied from 8020.3 ± 0.6-11140.3 ± 0.6µS/cm, Cation Exchange Capacity varied from 0.017 ± 0.000115-0.024 ± 0.000058 Meq/100g, Total Nitrogen varied from 0.06 ± 0.00115-0.22 ± 0.00115%, Total Organic Carbon (TOC) varied from 22.31 ± 0.0115mg/g and Bulk Density varied from 1.38 ± 0.00115-1.51 ± 0.00577g/cm^3(Table 3).

Location	pH	EC (µS/cm)	CEC Meq/100g)	Total N (%)	TOC (mg/g)	Bulk Density (g/cm^3)
Choba	8.963 ± 0.06^b	11140.3 ± 0.6^a	0.022 ± 0.0173^b	0.18 ± 0.058^b	22.31 ± 0.0115^c	1.51 ± 0.0577^a
Rumuok-wurushi	9.033 ± 0.06^a	8380.7 ± 0.6^b	0.017 ± 0.0115^c	0.06 ± 0.0115^c	33.20 ± 0.058^b	1.38 ± 0.0115^b
Oginigba	8.943 ± 0.06^c	8020.3 ± 0.6^c	0.024 ± 0.0058^a	0.22 ± 0.0115^a	37.93 ± 0.0577^a	1.51 ± 0.0577^a

Table 3: Soil chemical characteristics of the study area.

Soil Properties	Cu	Cr	Cd	Zn	Pb	Fe
pH	-0.57 0.109^{ns}	0.549 0.126^{ns}	-0.344 0.365^{ns}	-0.861 0.003	-0.289 0.451^{ns}	0.404 0.281^{ns}
EC	-0.685 0.042	-0.928 0.000	0.989 0.000	-0.312 0.414^{ns}	-0.878 0.002	-0.977 0.000
CEC	0.621 0.074^{ns}	-0.503 0.167^{ns}	0.291 0.448^{ns}	0.894 0.001	0.347 0.360^{ns}	-0.352 0.353^{ns}
Total Nitrogen	0.600 0.088^{ns}	-0.527 0.145^{ns}	0.317 0.406^{ns}	0.882 0.002	0.321 0.399^{ns}	-0.378 0.317^{ns}
Total Organic Carbon	0.812 0.008	0.839 0.005	-0.942 0.000	0.489 0.182^{ns}	0.953 0.000	0.918 0.000
Bulk Density	0.387 0.303^{ns}	-0.715 0.030	0.536 0.137^{ns}	0.740 0.023	0.082 0.834^{ns}	-0.590 0.095^{ns}

ns = not significant; pH was not significant in all the trace metals apart from zinc and ranged from 0.003-0.451, electrical conductivity was significant in all the trace metals apart from zinc and ranged from 0.000-0.414, cation exchange capacity was notsignificant in all the trace metals except in cadmium and ranged from 0.001-0.448, total nitrogen was not significant in all the trace metals except in zinc and ranged from 0.002-0.406 and total organic carbon was significant in all the trace metals except in zinc and ranged from 0.000-0.182 (Table 4).

Table 4: Relationships between soil chemical properties and heavy metal uptake in plants.

Heavy metal	THQ	HRI
Cu	0.111	9.825
Cr	0.001	0.085
Cd	0.432	38.000
Zn	0.074	6.593
Pb	0.413	36.57
Fe	0.477	42.289
HI = ΣTHQ	1.508	

Table 5: THQ and HI of Telfairiaoccidentalis in exposed population.

3.2 Results of calculated health risk parameters

The THQ ranged from 0.001-0.477 (Table 5)

The HI value was 1.508 (Table 4.5)

The HRI ranged from 0.085-42.289 (Table 5).

Heavy Metal	DIM (mg day^{-1} person^{-1})	* DI (mg day^{-1} person^{-1})	* UL (mg day^{-1} person^{-1})
Cu	0.393	0.9	10
Cr	0.127	-	-
Cd	0.038	0.000	0.064
Zn	1.978	8	40
Pb	0.128	0.000	0.240
Fe	27.488	8	45

* Recommended daily intake (DI) and upper tolerable daily intake (UL) levels of heavy metals in foodstuffs (FDA, 2001; [28]; The DIM ranged from 0.038-27.488 (Table 6).

Table 6: Daily intake rate (mg day^{-1} person^{-1}) of heavy metal in vegetable.

4. Discussion

4.1 Concentration of heavy metals in *Telfairia occidentalis*

Mean concentration of Pb in the plant samples ranged from 1.00 ± 0.00-2.01 ± 0.01mg/kg. It was found to be highest in Oginigba, followed by Iriebe, Rumuokoro and Eneka with mean values of 2.01mg/kg, 1.51mg/kg, 1.51mg/kg and 1.00mg/kg respectively. These values exceeded the [29] allowable limit of 0.3mg/kg for edible plants [30]. The heavy metal significantly ($p<0.05$) affected the *Telfairia occidentalis* plant in the study area Likewise, the soil Pb which ranged from 5.00 ± 0.01-8.50 ± 0.0004mg/kg. The soils of the area were significantly affected with heavy metals. The soil Pb value is higher than that of plant. Therefore, the high plant Pb value may be due to absorption of soil lead by plants [7]. This result collaborates the work of [9] , who reported that *Telfairia occidentalis* has the ability to absorb lead. Soil Pb in the study area may be due to erosion of Pb based paints, waste from battery and additives from gasoline [31].

Mean concentration of plant Zinc in the study area ranged from 7.56 ± 0.01-36.77 ± 0.0204mg/kg. It was found to be highest in Rumuokoro and lowest in Rumuodara with mean values of 36.77mg/kg and 7.56 respectively. The plant Zinc concentration did not exceed [27] allowable limit of 99.40mg/kg. Similarly, the soil Zinc ranged from 15.82 ± 0.01-51.50 ± 0.0104mg/kg. In this study, the soil Zinc is higher than the plant Zinc concentration. This finding is in agreement with Kalagbor, et al, (2018b) who opined that fluted pumpkin can absorb Zinc. The source of zinc in the study area may be due to steel processing or burning of waste. Although, Zinc is an essential trace element necessary for human health, but high concentrations of zinc can lead to adverse health effects such as anosmia (the loss of the sense of smell) damage to the lungs, liver, kidney, heart and central nervous system [32] The Cadmium concentration in the plant ranged from 0.35 ± 0.00-0.55 ± 0.0104 mg/kg. It was found in Eliozu, Rukpakwulusi and Rumuokoro with mean values of 0.55mg/kg, 0.45mg/kg and 0.35mg/kg respectively. These values exceeded the WHO/FAO safe limit of 0.2mg/kg for Zn. Result is significant at $P<0.05$. Similarly, the soil Cadmium ranged from 0.35 ± 0.001-3.45 ± 0.00204mg/kg. Result is significant at $P<0.05$. The soil Cadmium is higher than the plant Cadmium. This result is in line with [9, 33] who found out that Cd exceeded the WHO/FAO safe limit in vegetables. Since the three locations with high Cd levels are areas with high traffic density, the result is also in agreement with [34] who found out that heavy metal contents of vegetable were higher in areas with high traffic routes within Port Harcourt metropolis. The high plant Cd may be due to atmospheric deposition on the plant by vehicular emissions and absorption by plant from soil Cd. The source of Cd in the study area may be due to fossil fuel and cement from construction sites. Cadmium is a metal of great environmental and occupational concern as it has been classified as a known human carcinogen [35]. Also, excessive acute Cadmium exposure may lead to pneumonitis, bronchitis, pulmonary edema and gastrointestinal problem [31].

The plant Chromium was detected in Rumuokwurushi only with value of 1.49 ± 0.0104mg/kg. The plant Cr mean value of 1.49mg/kg is above the [28] allowable limit of 1.30. The soil Chromium concentration significantly ($P<0.05$) affected the study area and ranged from 12.77 ± 0.03-19.95 ± 0.0104mg/kg. The soil Cr was higher than the plant Cr. This result agrees with [30] who also detected Chromium in vegetable sample. The high plant Cr may be due to the absorption by plant. The source of Cr in the study area may be from welding and other anthropogenic activities. Although, Cr(III) is an essential nutrient for humans, excessive intake can cause skin irritation [36, 37] stomach ulcer, lung problem, kidney and liver damage, reproductive complication and weak immune system [38, 39].

Plant Copper was detected in Rukpokwu only with value of 4.62 ± 0.04mg/kg. The mean Cu value of 4.62mg/kg is less than the [27] safe limit of 73.0mg/kg. However, statistically it is significant at P<0.05. Also, the soil Copper ranged from 8.60 ± 0.01-17.51 ± 0.0104mg/kg. The Cu concentration in the soil significantly differed with that of the plants. This result collaborated the result of [30] who reported that Copper level in vegetable were within safe limits [12], also recorded the presence of Copper in *T.occidentalis*. The source of Copper in the study area may be linked to waste from electrical gadgets containing copper. Although Copper is an important trace element to living things, but exposure of the body to excessive Copper causes health problems such as immunotoxicity, gastrointestinal disorder, liver and kidney damage [40]. The Iron content in *Telfairia occidentalis* ranged from 261.42 ± 0.01-416.06 ± 0.0104mg/kg. It was highest in Iriebe. This value was less than the [29] permissible limit of 425.0mg/kg. However, it was significant at P<0.05. Likewise, the concentration of Fe in soil ranged from 857.69 ± 0.01-875.47 ± 0.0304mg/kg. Result showed that this value was significant at P<0.05. The Fe in plant is less than the concentration of Fe in soil. Similarly, this is in line with [30], who also did a similar work in Lagos and found out that Iron was the most abundant metal in the study. Also, [41] did a similar work in Port Harcourt and found out high Iron accumulation in vegetables. The presence of Iron in the study area could be attributed to Iron based waste materials in the area. Iron is very important for the survival of living things but excessive Iron in the body can result in nausea, constipation and reduced zinc absorption [42].

The trace metal pollution index (TPI) of the soil was in the order Oginigba (21.00) >Choba (19.92) >Rumuokwurushi (14.27). These values are relatively high and showed serious soil contamination. Similarly, soil Pb contamination was highest in this area. This may also be the cause of high Pb in fluted pumpkin leaf apart from atmospheric deposition and it may be due to high industrial activities in this location. In terms of location, heavy metal contamination was in the order Iriebe (440.16mg/kg) > Oginigba (417.37 mg/kg) > Rumuokwurushi (408.12 mg/kg) > Eneka (379.14 mg/kg) > Rumuokoro (336.64 mg/kg) > Rukpakwulusi (318.39 mg/kg) > Rukpokwu (307.48 mg/kg) > Rukpakwulusi (306.36 mg/kg) > Choba (297.54 mg/kg) > Rumuodara (268.98). Iriebe recorded highest heavy metal contamination followed by Oginigba. The two areas are areas of serious industrial activities in the study area. Oginigba is the area where the popular T/Amadi is located. However, Rumuodara recorded the least heavy metal contamination. Rumuodara is more of a residential area and the sample was gotten from a garden inside a residential compound, this may be the reason it recorded the least value, however, all the trace metals detected are statistically significant. Also, the trace metals were not evenly distributed across the study area. Zn, Pb and Fe were found in the ten locations. However, Cu was found in Rukpokwu only, Cr was found in Rumuokwurushi only and Cd was found in Rumuokoro, Eliozu and Rukpakwulusi only. The variations recorded in the presence of heavy metals in the different locations could be attributed to different activities going on in the locations.

Generally, soil heavy metal contamination was more than that of the vegetable. Mostly, soil physicochemical properties are responsible for plant metal uptake. Statistically, pH was significant in zinc. It has been established that heavy metal uptake by plants is pH dependent [43].The pH of the location under study was slightly alkaline. Total nitrogen and cation exchange capacity were not significant in all the trace metals apart from in zinc. Contrary, total organic carbon and electrical conductivity were significant in all trace metals apart from in zinc. Bulk density was significant in chromium and zinc only. And the soil of the study area was sandy clay loam. All these factors have interactive effect on heavy metals uptake from soil. It has further been established that washing of vegetables significantly reduce heavy metal concentration and thus suggest that atmospheric deposition on vegetables is a major route of contamination of vegetables in urban areas apart from adsorption of heavy metals by plants [9].

4.2 Health risk assessment

The Target Hazard Quotient is a ratio between the measured concentration and the oral reference dose, weighted by the length and frequency of exposure; amount ingested and body weight [44]. THQ value greater than 1 showed that a population is at risk of metal contamination.The THQ of Cu, Cr, Cd, Zn, Pb and Fe were 0.111, 0.001, 0.432, 0.074, 0.413 and 0.477 respectively (Table 4.5). From the result, the risk exposure of the target population to heavy metal was in the order Fe>Cd>Pb>Cu>Zn>Cr. The THQ of all heavy metals in this study was less than 1; therefore, it does not call for health concern [25] did a similar work at Lagos and found out that Cd, Pb, Cu, Zn and Cr did not pose health concern to the inhabitants of the study area.

DIM refers to the quantity of metal taken by an individual per day. The DIM results in table 6, were compared with the tolerable daily intake for metals as recommended by WHO (1989) and Institute of Medicine (2001) [28]. It is obvious that the daily intake of Cu (0.393) and Zn (1.978) are lower than the recommended daily intake level of metals and the tolerable upper intake level (UL). But the DIM of Pb (0.128), Cd (0.038) and Fe (27.488) exceed the recommended daily intake level, however, fall within the tolerable upper level. Cr (0.127) is lower than the recommended oral reference dose (RfD) of 1.5mg/kg. However, the tolerable upper intake level for Cr has not been established. Since, the DIM of Pb, Cd and Fe are above the recommended daily intake, the inhabitants may be at risk of exposure to metals if the value increase above the UL. This result corroborates the work of [25].

The HRI of Cu, Cr, Cd, Zn, Pb and Fe were 9.825, 0.085, 38.000, 6.593, 36.570 and 42.289 respectively. Generally, HRI < 1 means that the exposed population is safe from metals health risk while HRI > 1 means the reverse [25, 45]. In this study, the HRI of the metals considered are greater than 1 except Cr. Therefore, the inhabitants may be at risk of Cu, Cd, Zn, Pb and Fe exposure [25, 44] also gave similar reports on Cu, Cd, Zn, Pb and Cr. Hazard index (HI) is used to evaluate the potential risk to human health when more than one heavy metal is involved. HI >1 shows that a population is at risk. In this study, the HI was 1.508. This showed that the population may be at risk of consuming this vegetable.

The analysis of trace metals in leafy vegetables is very important because of its toxicity. These findings collaborates the work of [30], who investigated heavy metals Fe, Cu, Zn, Cr, Cd and Pb content in vegetable and found out that all the trace metals were of varying concentrations in the vegetable, and were below the WHO/FAO safe limits. The findings also collaborate with the work of [25], who did a similar work in Lagos, Nigeria and found out that vegetables including fluted pumpkin accumulate Cu, Zn, Cr, Cd and Pb at varying concentrations. He also found out that the THQ value of all the metals were below the permissible limits and therefore, did not pose risk, but with continuous consumption of vegetables the values may increase.

5. Conclusion

All the trace metals studied were found in fluted pumpkin in varying concentrations. Although, the trace metals were below the WHO/FAO acceptable limits but they were all statistically significant. The result also showed that areas with high industrial and traffic activities recorded higher values of heavy metals contamination while residential areas recorded the least. The HRI and HI values showed that the inhabitants may be at risk of heavy metal contamination. The DIM value showed that Pb and Cd were below the UL but exceeded the recommended value.

References

1. Akoroda MO. Ethnobotany of *Telfairia occidentalis* (Curcurbitacae) among Igbos of Nigeria. Economic Botany (1990): 29-39.
2. Oboh G, Akindahunsi AA. Change in the ascorbic acid, total phenol and antioxidant activity of sun-dried commonly consumed green leafy vegetables in Nigeria. J. Med.Food 8 (2004): 560-563.
3. Oathman OC. Heavy Metal in green vegetables and soils from vegetable gardens.Tanzanian Journal of Science 27(2001): 37-48.
4. Otitoju O, Akpanabiatu MI, Otitoju GTO, et al. Heavy metal contamination of green leafy vegetable Gardens in Itam Road Construction site in Uyo, Nigeria. Research Journal of Environmental and Earth Sciences 4 (2012): 371-375.
5. Odiaka NI, Odiaka EC. Gold mine in indigenous vegetables: The case of fluted pumpkin (Telfairiaoccidentalis Hook. F.) for economic growth. Acta Hort 911 (2011): 279-284.
6. Ikhajiagbe B Odigie, UE Oghogho, JI, Omoregbee O. Heavy metal contents and microbial flora of fresh leaves of fluted pumpkin (Telfairaoccidentalis), collected from road-side open markets in Benin Metropolis, Midwestern, Nigeria.Intl. J Biotech 2 (2013): 52-58.
7. Echem OG. Determination of the levels of heavy metal (Cu, Fe, Ni, Pb and Cd) up take of pumpkin (Telfairiaoccidentalis) leaves cultivated on contaminated soil. J. Appl. Sci. Environ. Manage18 (2014): 71-77.
8. Nwoko CO, Egunjobi JK. Lead Contamination of Soil and Vegetation in an abandoned battery

factory site in Ibadan, Nigeria. Journal of Sustainable Agriculture and Environment. 4 (2002): 91-96.

9. Nwoko CO, Emenyonu EN, Umejuru CE. Trace Metal Contamination of Selected vegetables grown around Owerri Municipality, Nigeria. Journal of Agriculture and Ecology Research International 1 (2014): 18-29.
10. Nwoko CO, Mgbeahuruike LO. Heavy metal Contamination of ready-to-use herbal remedies in South eastern Nigeria. Pakistian Jour. Of Nutrition 10 (2011): 959-964.
11. Zhang F, Yan X, Zeng C, et al. Influence of Traffic (2012).
12. Okon AI, Sunday WE, Peter IE. Determination of Heavy Metal Contents in Fluted Pumpkin Leaves (Telfairiaoccidentalis) Along Roadsides in Calabar, Nigeria.European Scientific Journal 11 (2015): 33.
13. Agbaire PO, Esiefarienrhe E. Air pollution tolerance indices (APTI) of some plants around Otorogu gas plant in Delta State, Nigeria.Journal of Applied Science and Environmental Management 13 (2009): 11-14.
14. Njoku-Tony RF, Ihejirika CE, Ebe TE, et al. Effects of Gas Flare from Utorogu Gas Plant on Biochemical Variables of Cassava Leaves (Manihotesculentum), Delta State.British Journal of Environmental Science 5 (2017): 1-13.
15. Ali MHH, Al-Qahtani KM. Assessment of some heavy metals in vegetables, cereals and fruits in Saudi Arabian markets.Egyptian Journal of Aquatic Research 38 (2012): 31-37.
16. Alaminiokuma GI, Ofuyah WN. Water table regime in parts of Obio-Akpor local Government area of Rivers State, Nigeria. International Research Journal of Earth Sciences 5 (2017): 9-16.
17. Eludoyin OS, Wokocha CC, Ayoalagha G. GIS Assessment of Land Use and Land Cover Changes in Obio/Akpor L.G.A., Rivers State, Nigeria. Research Journal of Environmental and Earth Sciences 3 (2011): 307-313.
18. Arokoyu S, Ogoro M, Jochebed O, et al. Petrol Filling stations' Location and Minimum Environmental Safety Requirements in ObioAkpor LGA, Nigeria.International Journal of Scientific Research and Innovative Technology 2 (2015): 21-39.
19. Egwuogu CC, Okeke HU, Emenike HI, et al. Rainwater Quality Assessment in Obio/Akpor LGA of River State Nigeria.International Journal of Science and Technology 5 (2016): 8.
20. Figueiredo CC, Sato JH, Marchão RL, et al. Methods of soil organic carbon determination in Brazillian savannah soils.Scientia Agricola 71(2014): 302-308.
21. Xiuli Z, Xinghui X. Total nitrogen and total phosphorous in urban soils used for different purposes in Beijing, China.Procedia Environmental Sciences 13 (2012): 95-104.
22. John NC. Geotechnical Engineering Soil Mechanics, John Wiley and Sons, Inc (1995).
23. Rubén AG, Susan F. USCS and the USDA Soil Classification System: Development of a Mapping Scheme. US Army Corps of Engineers. Engineer Research and Development Center (ERDC) (2015).
24. Curtis JO. Electromagnetic Poser Attenuation in Soils.ERDC/EL TR-05-5. Vicksburg, MS: U.S.

Army Engineer Research and Development Center (2005).

25. Adedokun HA, Longinus NK, Olatunde AM, et al. Potential Human Health Risk Assessment of Heavy Metals Intake via Consumption of some Leafy Vegetables obtained from Four Market in Lagos Metropolis, Nigeria.J. Appl. Sci. Environ. Manage 20 (2016): 530-539.
26. USEPA. UnitedStates Environmental Protection Agency.Toxic Relea Inventory 2011 Arizona (2011).
27. Kingsley CP, Uchenna NH. Potential Health Risk from Heavy Metals via Consumption of Leafy Vegetables in the Vicinity of Warri Refining and Petrochemical Company, Delta State, Nigeria. Annals of Biological Sciences 6 (2018): 30-37.
28. Garcia-Rico L, Leyva-Perez J, Jara-Marini ME. Content and daily intake of copper, zinc, lead, cadmium, and mercury from dietary supplements in Mexico. Food Chemistry and Toxicology 45 (2007): 1599-1605.
29. FAO/WHO. Codex Alimentarius Commission. Food Additives and Contaminants. Joint FAO/WHO Food Standards programme (2007).
30. Adu AA, Aderinola OJ, Kusemiju V. Heavy Metals Concentration in Garden Lettuce (Lactuca sativa L.) Grown Along Badagry Expressway, Lagos, Nigeria.Transnational Journal of Science and Technology2 (2012): 115-130.
31. ATSDR. Agency for Toxic Substances and Disease Registry.Public Health Service. Atlanta: U.S. Department of Health and Human Services. Toxicological Profile for Lead (1999).
32. Nriagu J. Zinc Toxicity in Humans. University of Michigan. Elsevier B.V (2007).
33. Fosu-Mensah BY, Addae E, Yirenya-Tawiah D,et al. Heavy metals concentration and distribution in soils and vegetation at Korle Lagoon area in Accra, Ghana, (Reviewing Editor). Cogent Environmental Science 3 (2017): 1.
34. Echem OG, Kabari LG. Heavy metals content in bitterleaf (Vernoniaamydalina) grown along heavy traffic routes in Port Harcourt, Nigeria.International J. Afr. Chem 1 (2012): 1-6.
35. NTP. National Toxicology Program. Cadmium and cadmium Compounds. In: 11th Report on Carcinogenesis. Research Triangle Park (2004).
36. Tavakkoli L, Nasab ZZ, Khanjani NN. Environmental and occupational exposure to chromium in Iran: A systematic review. Journal of Epidemiological Research 3 (2017).
37. Lenntech BV. Chromium - Cr (Chemical properties of chromium - Health effects of chromium - Environmental effects of chromium) (2018).
38. Lentech BV. National Bureau of Statistics (2006).
39. ATSDR. Agency for Toxic Substances and Disease Registry Chromium Toxicity - Case Studies in Environmental Medicine (CSEM) .Toxicological Profile for Asbestos (2018).
40. ATSDR. Agency for Toxic Substances and Disease Registry.Toxicological profile for Copper. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service (2004).

41. Kalagbor IA, Emmanuel SA, Oyewole DO. Bioavailability Study of Nine (Mn, Fe, Cu, Zn, Pb, Cr, Ni, Cd, Co) Heavy Metals in Four Edible Vegetables and a Crop Using AAS and EDS. American Journal of Environmental Engineering and Science 2 (2015): 23-34.
42. Edward Group. What Is Iron? Understanding This Essential Nutrient.Global Healing Center (2017).
43. Adamczyk-Szabela D, Markiewicz J, Wolf WM. Heavy Metal Uptake by Herbs. IV. Influence of Soil pH on the Content of Heavy Metals in Valerianaofficinalis L.Water, Air, & Soil Pollution 226 (2015): 1.
44. Tsafe AI, Hassan LG, Sahabi DM, et al. Evaluation of Heavy Metals Uptake and Risk Assessment of Vegetables Grown in Yargalma of Northern Nigeria. Journal of Basic and Applied Science Research 2 (2012): 6708-6671.
45. Khan S, Farooq R, Shahbaz S, et al. Health risk assessment of heavy metals for population via consumption of vegetables.World Appl. Sci. J 6 (2009): 1602-1606.